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Standard test method for measuring the heat release rate of low flammability mattresses and mattress sets

Méthode d'essai normalisée pour mesurer le débit calorifique de matelas et d'éléments de matelas à inflammabilité réduite

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12949 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Introduction

A typical bed consists of several components, including a mattress, a foundation, and a collection of bedclothes (e.g. mattress pad, sheets, pillows, blankets, quilts and/or comforters). Mattress and bedding fires are a major contributor to residential fire deaths [1]. A significant portion of these deaths and injuries results from fires in which the bedclothes are the first items ignited, and those flames ignite the mattress or foundation. In the United States, approximately two-thirds of all deaths from flaming bed fires occur after the room has reached the point of flashover [2]. This accounts for nearly all the fatalities that occur outside the room of fire origin and about half of the fatalities that occur within the room of origin.

A burning mattress is generally the primary energy contributor to a fatal bedroom fire. Once the mattress is ignited, the fire develops rapidly. Room flashover occurs at heat release rates near or above 1 000 kW (1 MW) for small-to-medium size bedrooms [3]. 1 m wide mattresses, without bedclothes, have been shown to reach peak heat release rates of 2 MW and flash over a room in less than 300 s [3]. In addition, a typical set of bedclothes on a 1 m wide bed can lead to a fire whose peak rate of heat release is approximately 100 kW to 200 kW [4], with values up to 400 kW possible for the heaviest sets [5]. A bed clothes fire can become appreciably more threatening on larger beds [6].

It follows that a significant reduction in bed fire fatalities can be achieved by reducing the combined peak heat release rate of a bed, the bedclothes, and other furnishings ignited by the bedclothes to a level well below 1 MW. Current regulation in the United States limits the peak rate of heat release of a mattress and foundation to 200 kW and the total heat release to 15 MJ during the first 10 min of the test [7], [8]. Combined with the typical heat release rate of the bedclothes, which generally occurs well before the peak heat release from the mattress, the overall heat release rate from the burning bed is substantially below the value that leads to room flashover. Furthermore, as the intensity of the bed fire is decreased this much, there is an accompanying reduction in the spatial extent of the radiant heat from flames. This reduces the likelihood that other bedroom furnishings will be ignited by the bed fire and greatly increases the time available for occupants to recognize and escape the fire.

This International Standard addresses a fire hazard scenario different from one in which a cigarette ignites the bed and threatens people who might be asleep on the bed with their heads near the location of the dropped cigarette. The resulting deaths most often result from inhalation of the toxic fumes from the smouldering fire and are distinct from the deaths that are to be averted by limiting the flaming intensity of the bed fire. In several countries, mattresses are tested for cigarette ignition resistance [9], which reduces the likelihood of smouldering fires, but infrequently addresses the fire hazard addressed by this International Standard.

Standard test method for measuring the heat release rate of low flammability mattresses and mattress sets

WARNING — So that suitable precautions can be taken to safeguard health, the attention of all concerned with fire tests is drawn to the possibility that toxic or harmful gases are evolved during combustion of test specimens.

The test procedures involve high temperatures. Hazards can therefore exist for burns and ignition of extraneous objects or clothing. The operators should use protective clothing, helmets, face-shields, and breathing equipment for avoiding exposure to toxic gases.

Laboratory safety procedures should be set up to ensure the safe termination of tests. It is imperative that adequate means of extinguishing such a fire are provided.

1 Scope

This International Standard provides a full-scale test method for determining the heat release rate and total heat release from a mattress or a mattress and foundation. The test specimen is ignited by exposure to a pair of gas burners that simulate burning bedclothes [5]. The measurement capability is designed for mattress sets of low flammability, i.e. having a peak rate of heat release below 300 kW.

This International Standard applies to mattresses and mattress and foundation sets. This International Standard does not apply to mattress pads, pillows, blankets, or other items used on top of a mattress.

This International Standard is a performance standard and does not prescribe the use of any specific components, fire retardant chemicals, or materials, and does not prescribe any design features that might lead to improved or degraded performance of a mattress set.

Annex A describes an analysis that indicates the potential reduction in life loss achievable by limiting the magnitude of the bed fire.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9705, *Fire tests — Full-scale room test for surface products*

ISO 13943, *Fire safety — Vocabulary*

ISO 24473, *Fire tests — Open calorimetry — Measurement of the rate of production of heat and combustion products for fires of up to 40 MW*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following apply.

3.1
foundation
ticking-covered structure used to support a mattress or other sleep surface

3.2
mattress
resilient material, used alone or in combination with other materials, enclosed in a ticking, and intended or promoted for sleeping upon

3.3
mattress set
mattress and foundation labelled for sale as a single unit or a mattress labelled for sale without any foundation

3.4
tape edge
edge made by using binding tape to encase and finish raw edges of a mattress or foundation

3.5
ticking
outermost layer of fabric or related material of a mattress or foundation

NOTE This does not include any layers of fabric or related materials that are quilted together with the outermost layer of fabric or related material.

4 Summary of test method

This test method measures the flammability performance of a mattress or mattress set by exposing the specimen to a specified flaming ignition source and allowing it to burn freely in a controlled test area. The test area shall be one of two configurations, either an open calorimeter, as in ISO 24473, or a test room meeting specified dimensions and connected to a collection hood. The flaming ignition source is specified as a pair of propane burners, simulating burning bedclothes, that impose differing heat fluxes for differing times on the top and side of the test specimen. Measurements of the time-dependent heat release rate from the test specimen are made during and after exposure to the specified burners in order to quantify the enthalpy generated by the fire. The rate of heat release is measured by oxygen consumption calorimetry derived from measurements in the exhaust duct. The test continues for 30 min or until there is a significant threat to the safety of test personnel and/or the test equipment and test facility.

5 Significance and use

This International Standard defines an apparatus and a process for measuring the rate of heat release and the total heat generated by a bed whose peak heat release rate is near or under 300 kW. This value, even combined with the heat release rate from bedclothes for a 1 m wide bed, is significantly lower than the heat release rate that results in flashover of a typical bedroom.

6 Apparatus and equipment

6.1 Test area

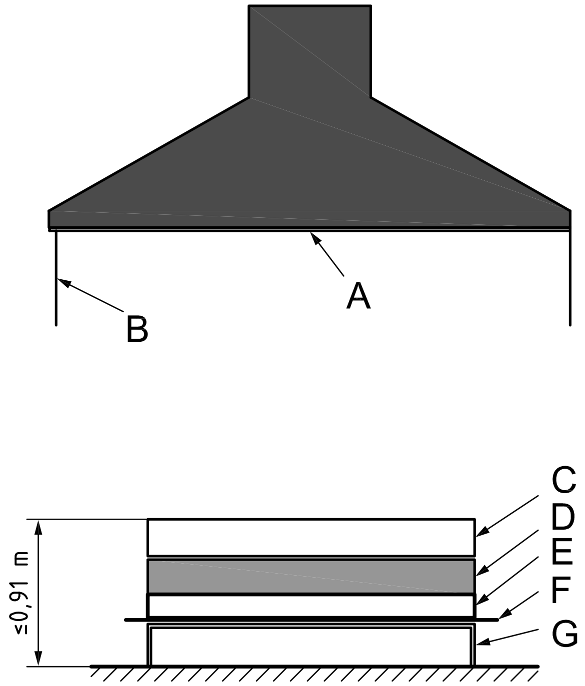
The test shall be conducted in an open calorimeter or in a test room.

6.1.1 Environmental conditions

The test area shall be maintained at a temperature greater than 10 °C and less than 30 °C and a relative humidity less than 75 %.

6.1.2 Open calorimeter

6.1.2.1 In this configuration (Figure 1), the specimen to be tested is placed under the centre of an open calorimeter whose characteristics are described in ISO 24473. The calorimeter shall be capable of measuring a heat release rate of 300 kW or lower, with a total uncertainty of no more than 20 kW.



Key

A calorimeter hood

B optional hood skirt

C mattress

D foundation

E bed frame

F catch surface

G elevated support (optional)

Figure 1 — Test assembly, shown under an open calorimeter

6.1.2.2 The area surrounding the test specimen shall be sufficiently large that there are no heat re-radiation effects from any nearby materials or objects.

6.1.2.3 The calorimeter hood shall capture the entire smoke plume and is instrumented for the measurement of the heat release rate using oxygen consumption calorimetry. The air supply to the hood shall be sufficient that the fire is not in any way limited or affected by the available air supply.

6.1.2.3.1 As needed, skirts shall be placed on the hood periphery to help assure capture of the entire smoke plume. Such skirts shall not be of such an excessive length as to cause the incoming flow to disturb the burning process. The skirts shall not heat to the point that they contribute significant re-radiation to the test specimen.

6.1.2.3.2 The fire plume shall not enter the hood exhaust duct.

NOTE Flickers of flame that last for a few seconds and occupy only a minor fraction of the hood exhaust duct inlet cross-section are acceptable because they do not signify appreciable suppression of flames.

6.1.2.4 The air flow to the test specimen shall be symmetrical from all sides. A small flame placed in the centre of the test specimen area shall not bend consistently in one direction.

6.1.2.5 The test specimen shall be placed on a test frame, which is to centred under the hood.

6.1.3 Test room

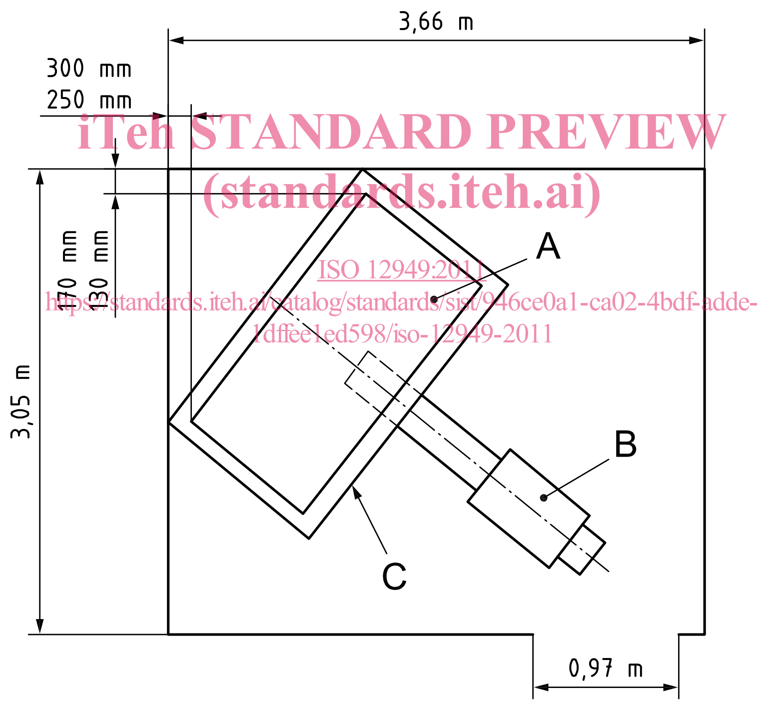
6.1.3.1 The test room (Figure 2) shall have dimensions of at least 3 m wide × 3 m deep × 2,4 m high.

NOTE 1 This is larger than the ISO 9705 test room.

NOTE 2 The larger room and the angled position of the bed in the room are necessary to minimize radiative feedback from the room walls to the bed, especially if there is burning along the side panels. Radiative feedback can increase the burning rate of the test specimen in a non-repeatable manner and can also lead to results different from those obtained in an open calorimeter.

NOTE 3 A room of these dimensions is sufficiently large to accommodate a mattress that is up to 1 000 mm wide and up to 2 000 mm long, along with the space needed for the movement of the burner assembly. To test larger mattresses, the minimum room dimensions are increased by the increases in the length and width of the larger test mattress over those of the twin mattress.

6.1.3.2 The room shall have no large openings permitting air infiltration other than a doorway opening (970 ± 5) mm wide and (2 030 ± 5) mm high, which shall be located as shown in Figure 2. There may be small openings necessary to make the prescribed measurements. There shall be no obstructions to the set-up in the air supply.



Key

A mattress and foundation on bed frame

B burner footprint

C catch surface

NOTE All dimensions are ±5 mm.

Figure 2 — Apparatus and specimen arrangement in test room

6.1.3.3 For video or photographic recording of the tests, there shall be at least one window to allow full view of the specimen, sealed with heat resistant glass, in one of the room walls. The window(s) shall be appropriately placed to obtain the required full-length view of the specimen (see 8.6).

6.1.3.4 An exhaust hood shall be positioned outside of and directly above the doorway so as to collect all of the combustion gases. The hood exhaust system shall be instrumented for oxygen consumption calorimetry measurements, as described in ISO 9705.

6.1.3.5 The test room shall be constructed of wood or metal studs and shall be lined with non-combustible material at least 12,7 mm thick.

NOTE Gypsum wallboard and calcium silicate board have been found to be suitable liner materials.

6.1.3.6 The test specimen shall be placed on a test frame in the test room as shown in Figure 2. One corner of the test specimen shall be 130 mm to 170 mm from the wall, and the other corner shall be 250 mm to 300 mm from the wall. The test room shall contain no furnishings or combustible materials except for the test specimen.

NOTE The angled placement is intended to minimize the interaction of flames on the side surfaces of the test specimen with the room walls.

6.1.4 Test area air flow

The horizontal air flow at a distance of 0,5 m on all sides of the test specimen at the mattress top height shall be no more than 0,5 m/s. If there is any visual evidence that the burner flames are disturbed by drafts during their exposure durations, the burner regions shall be enclosed on two or more sides by at least a triple layer of screen wire. The screens shall be at least 250 mm high. The screen(s) for the top burner shall sit on the mattress top and shall be wide enough to extend beyond the area of the burner impingement. All screens shall be far enough away (typically 300 mm or more) from the burner tubes so as not to interfere or interact with flame spread during the burner exposure. The screen for the side burner will require a separate support from below. All screens shall be removed at the end of the 70 s exposure interval.

NOTE The objective is to keep the burner flames impinging on a fixed area of the specimen surface rather than wandering back and forth over a larger area.

6.1.5 Heat release rate calibration

The oxygen consumption calorimetry system shall be calibrated at a minimum of two calibration points, 75 kW and 200 kW, using the procedures in ISO 24473 for open calorimetry or ISO 9705 if a test room is utilized.

6.2 Test frame

6.2.1 The test specimen shall be supported around its perimeter by a test frame with a flat surface and no edges extending up from the surface. The frame shall be made from a welded, nominally 40 mm steel angle. The top surface of the frame shall be flat, with no edges extending up from the surface, i.e. the angle is configured downward. The outer dimensions of the test frame shall be within 5 mm of the outer dimensions of the test specimen. The frame shall be completely open under the test specimen except for two crosspieces, each 25 mm wide, and located at the one-third length points. If the sagging of the specimen between the crosspieces exceeds 19 mm below the frame, a minimal number of additional crosspieces shall then be added to prevent such sagging of the specimen.

6.2.2 The test frame shall be 115 mm high, except if adjustments are necessary to accommodate the required side burner position. The height of the frame shall also be adjusted, as necessary, so that the burner is no less than 25 mm above the supporting surface of the frame.

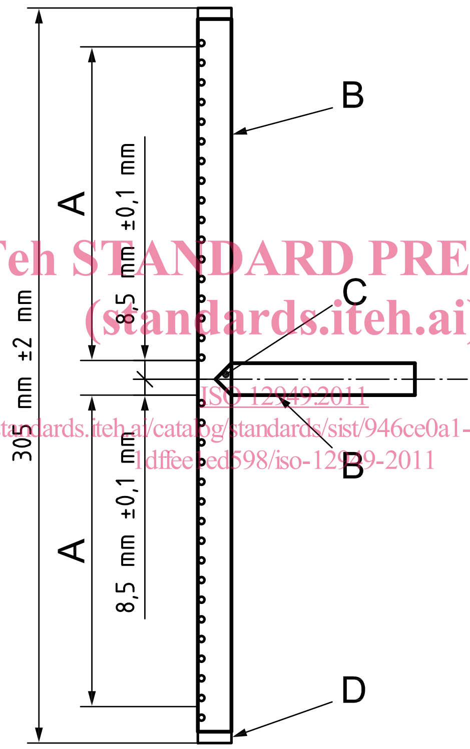
6.2.3 The test frame feet shall rest on a surface of either calcium silicate board or fibre cement board, 13 mm thick, and 200 mm wider and longer than the outer dimensions of the test specimen. The top surface of this board shall be cleaned between tests to avoid build-up of combustible residues. Lining this surface with aluminium foil to facilitate cleaning is not recommended because this might increase fire intensity via reflected radiation.

NOTE The board serves as a catch surface for any flaming melt/drip material falling from the bed assembly and can thus be the location of a pool fire that consumes such materials.

6.3 Ignition source

6.3.1 General

The ignition source shall consist of two T-shaped burners, shown in Figures 3 and 4. One burner impinges flames on the top surface of the mattress; the second burner impinges flames on the side of the mattress and on the side of the foundation. Each of the burners shall be constructed from stainless steel tubing (12,7 mm diameter with 0,89 mm ± 0,05 mm wall thickness). Each burner shall incorporate a standoff foot to set its distance from the test specimen surface (Figure 5). Both burners shall be mounted with a mechanical pivot point. The side burner is locked in place to prevent movement about this pivot in normal usage. The top burner is free to rotate about its pivot during a burner exposure and is lightly weighted so as to exert a downward force on the mattress top through its stand-off foot so that the burner follows a receding top surface on the test specimen. The combination of burner stand-off distance and propane gas flow to the burners determines the heat flux they impose on the surface of the test specimen. The top burner is set to generate a nominally 18 kW flame for 70 s; the side burner is set to generate a nominally 9 kW flame for 50 s.



Key

A 17 holes spaced over 135 mm length, pointing 5° out of the plane of the diagram

B stainless steel tubing

C gas-tight weld at 90° angle

D top and bottom end caps with gas-tight welded seal

Figure 3 — Details of horizontal burner head